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ABSTRACT

Twenty-three activities dealing with various aspects of groundwater are provided in this manual. The activities are arranged under four headings: (1) the water cycle; (2) water distribution in soils (considering such topics as calculating water table depth and purifying water by filtering); (3) water quality (considering such topics as acid rain, carbon dioxide in water, nitrates in groundwater, and total suspended solids); and (4) community aspects (investigating such areas as groundwater rights, farmers and water pollution, how a settling tank works, and groundwater pollution). Each activity includes the recommended grade levels for the activity (ranging from grade 3 to grade 12), objectives, list of materials needed, procedures, background information, list of references, student worksheet, and suggested follow-through activities. (JN)

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GROUNDWATER: A VITAL RESOURCE

STUDENT ACTIVITIES

COMPILED BY CEDAR CREEK LEARNING CENTER IN COOPERATION WITH THE TENNESSEE VALLEY AUTHORITY

SE 046182

Groundwater lies beneath the surface of the earth, filling the pores and fractures of soil and rock. It can be collected from wells or found flowing naturally to the surface from springs. It also sustains the flow of surface streams in dry weather, especially in highly permeable areas.

Nationally, groundwater is used, wholly or in part, to supply 35 percent of the public's water systems. In the Tennessee Valley, over 64 percent of the region's residents utilize groundwater totally or in part for drinking water. For every public surface water supply system, there are three groundwater systems.

Generally, the quality of the Tennessee Valley's groundwater is considered to be good enough to support existing water supply uses even though some minimal treatment, such as chlorination, might be recommended. When pollution occurs in a groundwater source (aquifer), it is virtually impossible to clean. Contamination can come from a multitude of sources, including improper waste disposal, mining, agricultural activities, septic tanks, industry, and general urbanization activities. Prevention of such contamination is the best long-range solution.

Increasing public awareness and general education efforts will provide a better understanding of this vital resource and will serve to facilitate development of a conservation ethic among our citizens. It is our hope that such an attitude will bring about actions effecting a significant improvement of the quality and use of groundwater in the region.

Donna Ann Lifur
Environmental/Energy Education Program

The Tennessee Valley Authority has been charged "to aid further the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and of such adjoining territories..." The primary objective of the Tennessee Valley Authority's regional groundwater activities is for the maintenance of groundwater quality by protecting it from contamination.

Michael Matthews
Water Quality Branch
Regional Water Management Program

This activity series represents an effort by TVA to instill a sense of groundwater worth in Valley schools. It would not have been possible without the assistance of many individuals and contributing organizations. The activities in this book were developed or contributed by educators participating in a workshop series on groundwater sponsored by:

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The Tennessee Valley Authority wishes to acknowledge those participants who have successfully completed a unit on groundwater resources by awarding them with a certificate of appreciation. Please provide the following information:

- —Teachers'/Leaders' name
- —Name and mailing address of school, district name/organization name
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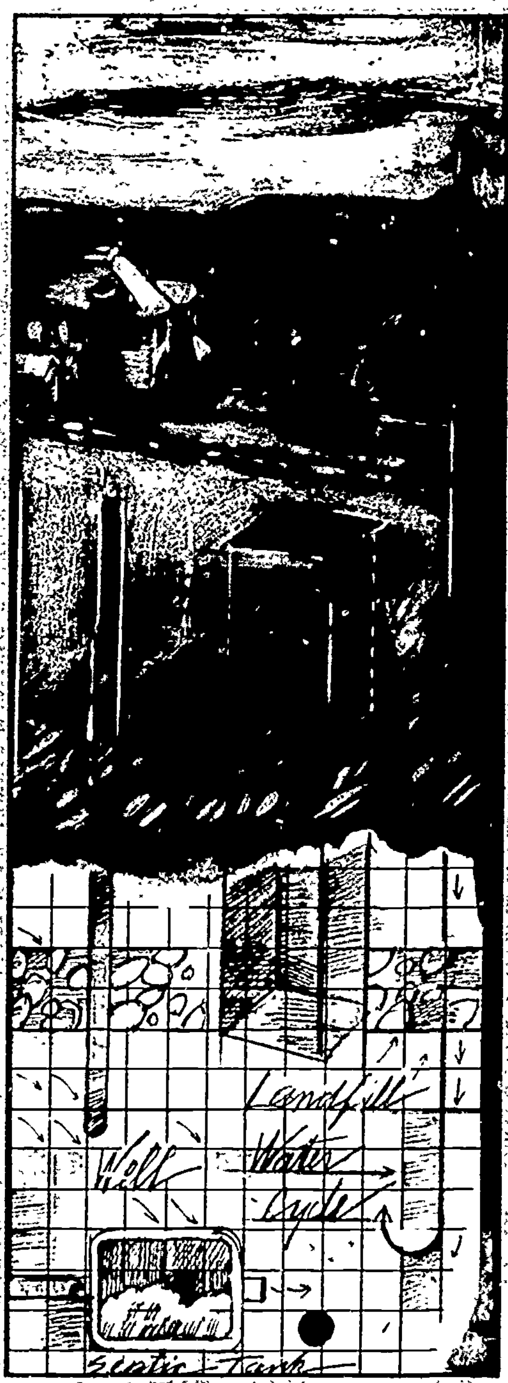


THE WATER CYCLE

BEST COPY AVAILABLE

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT GRADES 9-12

OBJECTIVES

Upon completion of the activities and when asked to diagram, demonstrate, or respond either orally or by writing, the participants will:

1. determine the importance of a biotic community and how it relates to our own community
2. demonstrate that plants and animals within a given community are interdependent
3. develop the concept that environmental conditions on land vary to a greater degree than they do in water

MATERIALS

- —meter or yard stick
- —tin can
- —phenolphthalein solution
- —manganese sulfate
- —potassium hydroxide
- —cork stoppers
- —sodium thiosulfate
- —microscope
- —thermometer
- —pH paper
- —sodium hydroxide solution
- —100 ml flask
- —potassium iodide
- —dilute sulfuric acid
- —eye dropper
- —plankton net

PREPARATION (SEE BACKGROUND INFORMATION)

PROCEDURE

1. Present background information as a short lecture/introduction.
2. Select a pond or stream located near your school.
3. Hand out activity sheets for recording data.
4. Divide the class into groups to collect data.
5. Discuss findings.
6. Return to area about a week later to observe growth and development.

FOLLOW-THROUGH

Streams and ponds are fascinating subjects for study, with applications to many areas of biology. Be prepared to answer questions from participants with a renewed interest in science

REFERENCES

Kingsport City Schools, *Investigations For A Mobile Environmental Education Laboratory*, 1972.

Phillips, Roger, E., Jr., A Field Trip to the Stream, *Carolina Tips*, Vol. 47, No. 2, 1984.

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

BACKGROUND INFORMATION

A dynamic biotic community is dependent upon the integration of the physical, chemical, and biological environmental factors. What better way for participants to see this relationship than to visit a nearby stream? The transition periods from summer to fall and from winter to spring are perfect times to take your class on a field trip. A stream of some sort can usually be found within walking distance of your school.

What characteristics determine the life in a stream? Many factors are involved. The velocity of the stream is probably the most important. Stream velocity determines what type of food is present and what feeding strategies are used by the organisms. It also plays a large part in the dissolved oxygen content of the stream. Organisms are adapted to different stream velocities. Darters live in swift water, while sunfish spend most of their time in pools.

Dissolved oxygen content is another important factor. The cool temperatures of mountain streams when combined with the large number of waterfalls and riffles, result in water with high oxygen content. When water temperatures rise, dissolved oxygen goes out of solution and into the atmosphere.

The pH level also affects the distribution of life in a stream. The higher the pH, the more carbonates, bicarbonates, and salts present. Streams rich in these are nutritionally rich and support abundant life. When the pH is 10 or more, the stream will not be conducive to optimum levels of life. When the pH is 5 or below, the water will be too acidic for most life forms.

The bottom type of the stream plays a very important role in determining what types of organisms will be present and also influences the overall production of minerals in the stream. Sandy bottoms are the least productive, as they offer little substrate for either protection or attachment. It is important for many bottom-dwelling organisms to have a place of attachment to keep them from being swept away by the current. Bedrock is also essentially non-productive, because while it does offer a solid substrate, all life is totally exposed to the current. Gravel and rubble bottoms are the most productive. These bottom types offer large areas for attachment sites and provide abundant nooks and crannies in which crustaceans and insects and their larvae can hide.

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

ACTIVITY SHEET

Visit a stream located near your area. Examine the various features of your biotic community by answering the following questions on the data sheets provided by your teacher.

A. 1. How wide is the pond or stream?
   2. What is the average depth?
   3. Is it sheltered by trees?
   4. Does the sun shine on any portion of your community?
   5. Make a list of the living things you observe in the community.
   6. Is there a variety of plants and animals?
   7. How many animal populations are represented?
   8. What plants do you find growing on the bank? What plants are found growing on rocks?
   9. Do any of the plants grow in the water?

B. 1. On your data sheet, keep a record of the plant and animal relations that you observe. Is there any evidence that the plants help the animals? In what way do the animals help the plants? What kind of relationship is this called? Are there any changes in either plant or animal life from week to week? Can you observe the growth and development of living things in either community?
   2. Compare your list of observations with those of your classmates.

C. 1. Is there a relationship between the living and nonliving things in your community?
   2. What is the food chain in the community?
   3. Can this food chain be traced?
   4. Is your selected biotic community polluted or becoming polluted? What are the causes of this pollution?
   5. What changes are taking place in the stream?
   6. What factors are involved in becoming adapted to a certain community?
   7. From your observations, what do the location and the amount of sunlight have to do with the population growth in the stream community?

ACTIVITY SHEET
(Continued)

D. 1. Mapping

Draw an outline map of the stream or pond. Show the scale of your map and indicate which way is north. Include both natural and manmade features in your map. Label trees, islands, dams, piers, swampy ground, roads, hillsides, and buildings. Make your map as detailed as possible.

2. Water Depth

Carefully measure the water depth at various places. Keep a record of the measurements. You might use a long pole and weighted string to obtain various depth measurements.

3. Temperature

Using a thermometer, make a detailed record of both the air temperature and the water temperature of your community. Keep in mind that the sun affects the water temperature in shallow and deep parts.

4. Clearness

On your data sheet, record the clearness of the water. Is it clear or murky? How far does the light penetrate the water? At what depth can you no longer see?

E. Chemical Characteristics

1. Testing the pH of the Water

Is the water neutral, slightly acid, or slightly alkaline? Using the pH paper, compare the color of the pH paper with the colors on the chart provided with the pH paper kit. How does the pH of the water affect plant and animal life in a water community?

2. Carbon Dioxide Content

Carefully add 10 drops of phenolphthalein solution to 100 ml of stream water. Slowly add some sodium hydroxide solution with an eyedropper. Add the sodium hydroxide one drop at a time. Stir thoroughly after each addition. Continue adding sodium hydroxide until a permanent pink color develops. Use the following formula to determine the carbon dioxide content of the stream water: Sodium hydroxide X 140 = amount of CO_2 in water in parts per million.

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

ACTIVITY SHEET
(Continued)

3. Oxygen Content

Immediately after getting a sample of water from your biotic community, add 1 ml of manganese sulfate to a flask or bottle containing 100 ml of fresh water. Then add 1 ml each of potassium hydroxide and potassium iodide. Stopper the flask and mix thoroughly. Then add 1 ml of dilute sulfuric acid. Put the stopper back in the flask and mix the solution again. Let the water stand for 10 minutes. After this time, add sodium thiosulfate to the water with an eye dropper. Count each drop that you add. Continue until a permanent color change appears. Determin he oxygen in the stream by using the following formula:

Sodium thiosulfate drops X 28 = amount of oxygen in water in parts per million.

F. Biological Characteristics

1. Shoreline or Bank Vegetation

What kind of plants grow along the banks? Reeds? Long grasses? Cattails? Describe and identify, if possible, the different plants that grow along the bank or shore. Can you explain why some plants grow there and others do not?

2. Aquatic Vegetation

What kinds of plants are growing in the water? Do any of these resemble aquarium plants? Are there water lilies? Do the aquatic plants grow in shallow or deep water?

3. Plankton

All microscopic life swimming or drifting in the pond or stream can be termed plankton. Make a plankton tow net to obtain samples. Remove the cover and the bottom from a coffee can. Tie a nylon stocking around the can. Cut a hole in the toe of the stocking and tie a small empty bottle to it (a spice bottle will work well). Punch three holes around the edge of the coffee can for your tow line. Tow the plankton net from one end of your area to the other. Examine the plankton under a microscope provided by your teacher. What kind of organisms do you find? Are there more of these organisms at certain depths? How does this affect the aquatic community?

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

DATA SHEET—PHYSICAL CHARACTERISTICS

Location of Pond or Stream	Estimate Size of Pond or Stream	Average Depth	Type of Vegetation, Trees, Shrubs, etc.	Kind of Animal Life	Number of Different Animal Populations	Number of Plant Populations

DATA SHEET ANALYSIS—PLANT AND ANIMAL RELATIONSHIPS

Kind of Animal	Kind of Plant	Change in Plant or Animal Life. Change or None	Growth Development Positive or Negative

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

DATA SHEET ANALYSIS

Brief Sketch or Map Diagram Showing Habitat Location	Water Depth Measurements Average	Temperature		Clearness of Water		
		Air	Water	Clear	Murky	Other

CHARACTERISTICS OF AN AQUATIC ENVIRONMENT

DATA SHEET ANALYSIS
CHEMICAL CHARACTERISTICS
BIOLOGICAL

pH of Water	Carbon Dioxide Content	Oxygen Content	Aquatic Vegetation	Type of Microscopic Organism

DATA SHEET ANALYSIS
HABITAT CHARACTERISTICS

Sketch or Description of Food Chain	Condition of Habitat— Polluted or Non-Polluted	Factors Involved in Plant or Animal Adaptation To Their Habitat	Effect of Location and Sunlight on Habitat		
			Good	Bad	No Effect

OBJECTIVE

The participants will be able to identify and describe what groundwater is and how the hydrologic cycle operates.

MATERIALS

—water	—"Nature's Waterwheel" (pages 1 and 2)
—hot plate	—pan of ice cubes
—pan of water	

PREPARATION (SEE BACKGROUND INFORMATION)

PROCEDURE

1. Give each participant a copy of "Nature's Waterwheel" (page 1).

2. Boil the water on the hot plate.

3. Hold the pan of ice cubes over the steam from the boiling water.

Steam from the boiling water condenses when it hits the cold ice cube pan. The condensed water then falls back to be changed to steam again, completing the cycle.

Discuss how water eventually seeps into the soil (infiltration) and forms groundwater.

1. Give each participant a copy of "Nature's Waterwheel" (page 2).

2. Sketch on the blackboard a diagram of the hydrologic cycle.

3. Have the participants complete their diagrams as you discuss and complete the diagram on the blackboard.

FOLLOW-THROUGH

CLASSROOM HYDROLOGIC CYCLE

As a final and lasting activity have the participants help construct a water cycle for the classroom.

Materials: Terrarium (aquarium), gravel, peat moss, soil, plants (ferns, mosses, etc.).

1. In the bottom of the terrarium, put a 1-inch layer of gravel for drainage.

2. Add a layer of peat moss and a layer of soil.

3. Place the plants in the terrarium, water lightly, and cover. (You should not have to add more water.)

NATURE'S WATERWHEEL

The plants will take the moisture from the soil and release it through their leaves. The water will condense on the terrarium and fall back into the soil. The terrarium works in the same way as the hydrologic cycle works on the earth.

REFERENCES

Bishop, Margaret S., Phyllis G. Lewis, Berry Sutherland, *Focus On Earth Science*, Charles E. Merrill Publishing Co., 1976.

Namowitz, Samuel N., and Donald B. Stone, *Earth Science* American Book Co., 1978.

Wilson, James, *Ground Water. A Non-Technical Guide*, Academy of Natural Sciences, 1982.

Causey, Homer, Nancy Causey, Charles Smelcer, *Activity Sheets for "Nature's Waterwheel."*

BACKGROUND INFORMATION

Hydrology is the study of the movement and distribution of the waters of the earth. In nature, water circulates through a system called the water cycle or hydrologic cycle. This cycle begins when heat from the sun causes ocean water to evaporate and become water vapor. The atmosphere holds the water vapor while the vapor gradually cools and forms clouds. The water eventually falls as rain or snow. Most rain and snow falls back into the oceans. But some falls on the land and flows back to the seas, completing the cycle.

There are two main sources of fresh water. (1) surface water and (2) groundwater. Surface water flows over the land in lakes, rivers, and streams. Groundwater seeps through the soil or through cracks and cavities in rock.

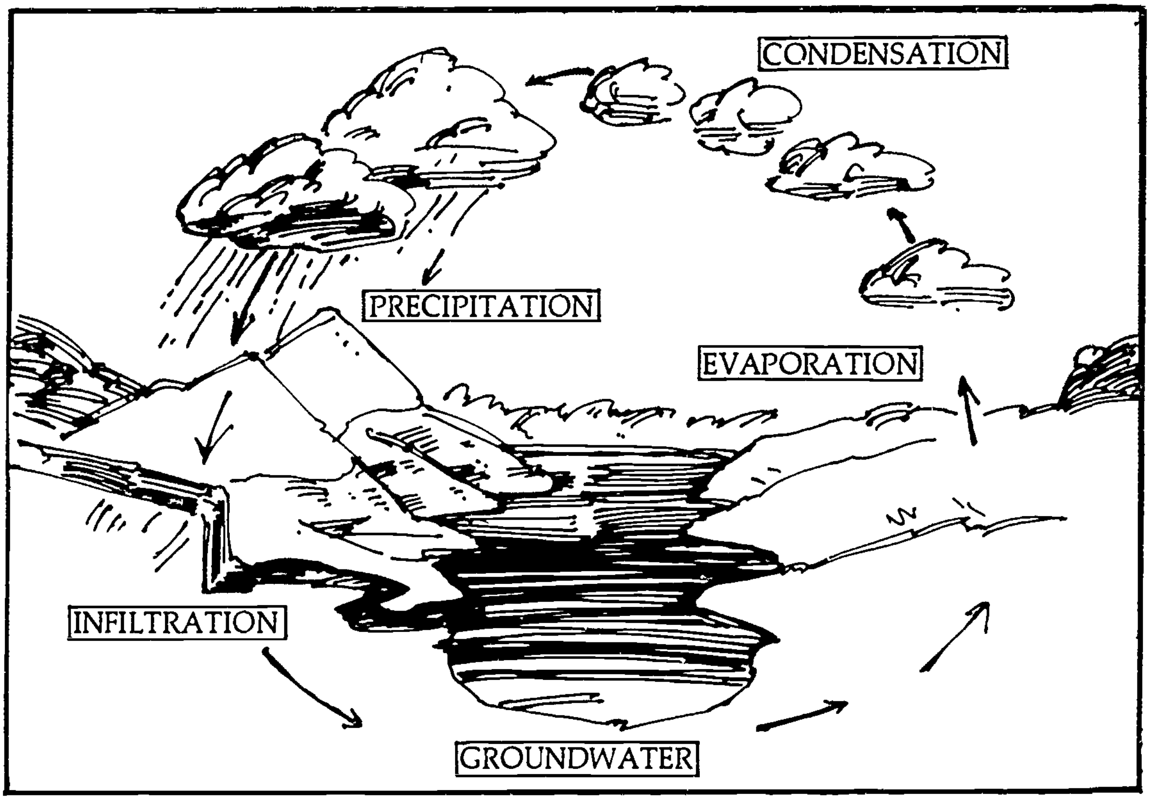
Groundwater is water beneath the surface of the earth. It is the source of water for wells and springs. Groundwater provides much of the fresh water in the United States. Most rural areas and some cities depend heavily on groundwater for their needs.

Groundwater accumulates chiefly from rain that filters through the soil. It also forms from water that seeps into the ground from lakes and ponds. The water settles into the pores and cracks of underground rocks and into the spaces between grains of sand and pieces of gravel. A layer or bed of such porous materials that yields useful amounts of groundwater is called an aquifer. Wells are drilled down to an aquifer to draw groundwater to the surface.

The surface of groundwater, called the water table, drops when more water is withdrawn that can be replaced naturally. In some areas that have large population or little rainfall, the groundwater supply may have to be recharged artifically. However, many regions of the world are using up the groundwater faster than aquifiers are being recharged. This lowering of the water table causes special problems in coastal areas, because salt water from the ocean enters reservoirs of groundwater.

Pollution of groundwater is a serious problem, especially near cities and industrial sites. Pollutants that seep into the ground can come from contaminated surface water, leaks from sewer pipes and septic tanks, and gasoline and chemical spills. Groundwater may also be polluted by chemical fertilizers and buried radioactive wastes.

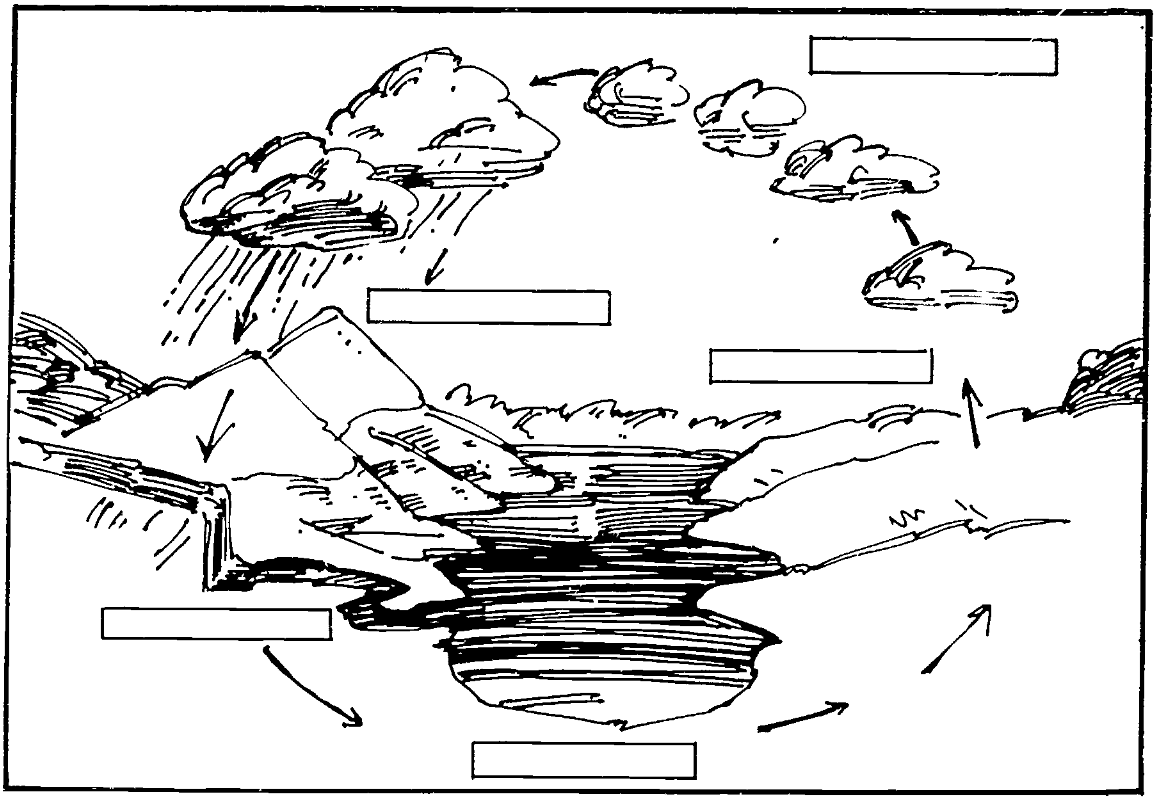
NATURE'S WATERWHEEL—ACTIVITY SHEET



WATER CYCLE *(HYDROLOGIC CYCLE)*

Think about the water on the ground. The water on the ground evaporates when the ground gets warm. Think about the warm air rising. The air and water vapor expand and rise high. The air is cooled when it rises. When the air is cooled, the water vapor condenses. The water vapor condenses to make clouds. Cloud drops come together to make bigger water drops. The bigger drops are rain. Rain falls on the ground. The water evaporates again. The whole cycle starts again. Water vapor condenses. Rain falls to the ground. This is the water cycle.

NATURE'S WATERWHEEL—ACTIVITY SHEET



WATER CYCLE ____________________

CONDENSATION—The changing of water vapor to liquid.

EVAPORATION—The changing of water into water vapor.

GROUNDWATER—Water found below the surface of the earth.

HYDROLOGIC CYCLE—Process involving the circulation and distribution of water on the earth.

INFILTRATION—The process by which water seeps into the soil.

PRECIPITATION—Forms of condensed water vapor that are heavy enough to fall to the earth's surface, such as rain, snow, sleet, hail, and fog.

OBJECTIVES

The participants will be able to determine the volume of water flow in a spring or stream.

The participants will be able to determine the type of spring or stream bed and reconstruct a profile of the spring or stream to ascertain how variations in the temperature, velocity, and plant life affect the amount of water available for use.

MATERIALS

—stopwatch
—sticks
—tape measure
—string
—meterstick

PREPARATION

Participant should be familiar with the measurement techniques used in this activity. Participants should receive orientation to basic concepts of water flow (gravity flow, etc.).

The volume of flow is important in pollution studies since it determines, to a large extent, the ability of a stream to handle pollutants that are added to it.

PROCEDURE

1. Hand out activity sheet. (In lower grades set up groups to gather information and recreate on board in classroom).

2. Follow instructions on activity sheet.

FOLLOW-THROUGH

1. Give participants several hypothetical streamflows for computating data.

2. Set scenarios of various water consumptive activities (industrial site, residential area, etc.) and have participants determine capability of stream to accommodate the needs.

REFERENCES

Field Study Manual For Outdoor Learning, Margaret Milliken, Austin F. Hamer, Ernest C. McDonald, Burgess Publishing Co., Minneapolis, MN.

A Guide to the Study of Environmental Pollution, 1972. W. A. Andrews, Prentice Hall, Englewood Cliffs, NJ.

STUDY OF A SPRING OR STREAM

ACTIVITY SHEET

1. INSTRUCTIONS FOR THE MEASUREMENT OF FLOW

   A. Measure and mark with stakes a 100-foot distance along a straight section of your stream.

   B. Find how fast the stream is flowing. Throw a stick (2 or 3 inches long) in the water above the upstream marker. Record the number of seconds it takes to float between the markers. Record below. No. of seconds to float between stakes: ________ seconds. Now divide the 100-foot distance by the total seconds it took the stick to float between the stakes. This will tell you how many feet the stick floated eacn second.

100 FT. ÷ ____________________ (SEC.)= ____________________ FT. PER SEC.
(DISTANCE) (TIME) (NUMBER OF FEET STICK FLOATED EACH SECOND)

   C. Find the average width of the section of the stream. Measure the width of the stream at 3 places within the 100-foot area. Record the measurements below. Divide the total by 3 to get the average width of the stream.

First Measurement ____________________ Feet

Second Measurement ____________________ Feet

Third Measurement ____________________ Feet

TOTAL ________________ Feet ÷ 3 = ________________ FT
(AVERAGE WIDTH)

   D. Find the average depth of the section of the stream. Wade across the stream in a straight line. Measure the depth of the stream in 3 places along the straight line. Record measurements below. Divide the total by 3 to get the average depth of the stream.

First Measurement ____________________ Feet

Second Measurement ____________________ Feet

Third Measurement ____________________ Feet ÷ 3 = ________________ FT
(AVERAGE DEPTH)

STUDY OF A SPRING OR STREAM

ACTIVITY SHEET

E. To find the flow volume (cubic feet of water per second), multiply the average depth times the number of feet the stick floated each second times the average width. This will tell you the number of cubic feet of water flowing in the stream every second.

______ X	______ X	______ =	______
(AVERAGE WIDTH)	(AVERAGE DEPTH)	(NUMBER OF FEET PER SECOND)	(CUBIC FT. OF WATER FLOWING PER SECOND)

NOTE: A cubic foot of water is the water in a container 1 foot wide, 1 foot high, and 1 foot long.

2. INSTRUCTIONS FOR PROFILE RECONSTRUCTION

A. Suspend a string across the width of the stream, its ends tied securely at each side.

B. At several intervals along the string, measure depth of the water, type of bottom material, and amount of vegetation.

C. For bottom type, you can use the system below of you can construct one of your own.

bedrock ________
mud or silt.......
rubble *****

sand xxxxx
gravel ooooo

D. When you have recorded your data, use a suitable scale to reconstruct the stream profile on paper.

WATER DISTRIBUTION IN SOILS

OBJECTIVE

Participants will relate the lake and stream elevations of a region to the variations of the water table depth.

MATERIALS

—topographic map
—ruler
—pencil, paper

PREPARATION

Participants should have been instructed in formation of topographic profile from line drawn along area of a topographic map.

1. Review: Read contour elevation on map
   Topographic profile preparation

2. Lecture:

   Precipitation migrates downward through soil and bedrock until all spaces are saturated. This lower level marks the upper surface of the local *water table*.

   The depth of the water table varies with local topographic irregularities, being slightly elevated under hills.

   As water within the saturated level above the water table migrates through the soil and bedrock, it follows gradients in the water table surface.

   When this slow-moving groundwater reaches an intersection of the water table with the land surface, a spring forms and the water is often added to a stream or lake.

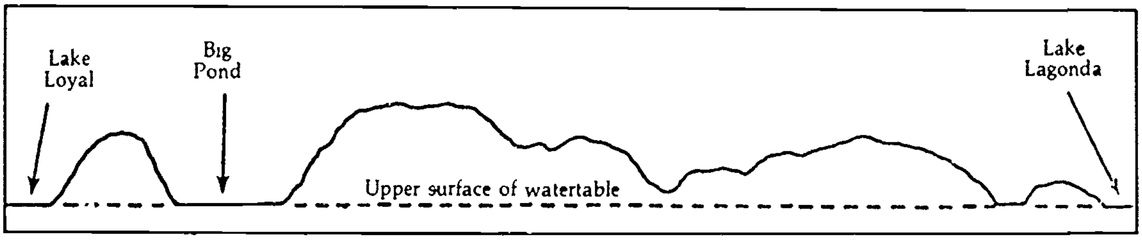
   A topographical map may be used to determine local variations in the water table depth.

   A profile map along a given line is constructed, including lakes, streams, sinkholes, and/or other water/land intersections. A line is drawn on the profile connecting the different water bodies. *Each lake is a local record of the water table level.*

CALCULATING WATER TABLE DEPTH

PROCEDURE

1. Construct a profile map of the area marked XY on the topographic map.



2. Connect lakes by dotted line; this indicates the water table.

FOLLOW-THROUGH (QUESTIONS)

1. What is the surface elevation (number of feet above sea level) at each of the 3 lakes taken from the topographic map?

   Lake Loyal: (100 ft.)

   Big Pond: (95 ft.)

   Lake Lagonda: (80 ft.)

2. In what general direction will the groundwater migrate in the area?

   (SE)

3. What is the average gradient of the water table surface in feet per mile?

   3/8 ft/mile

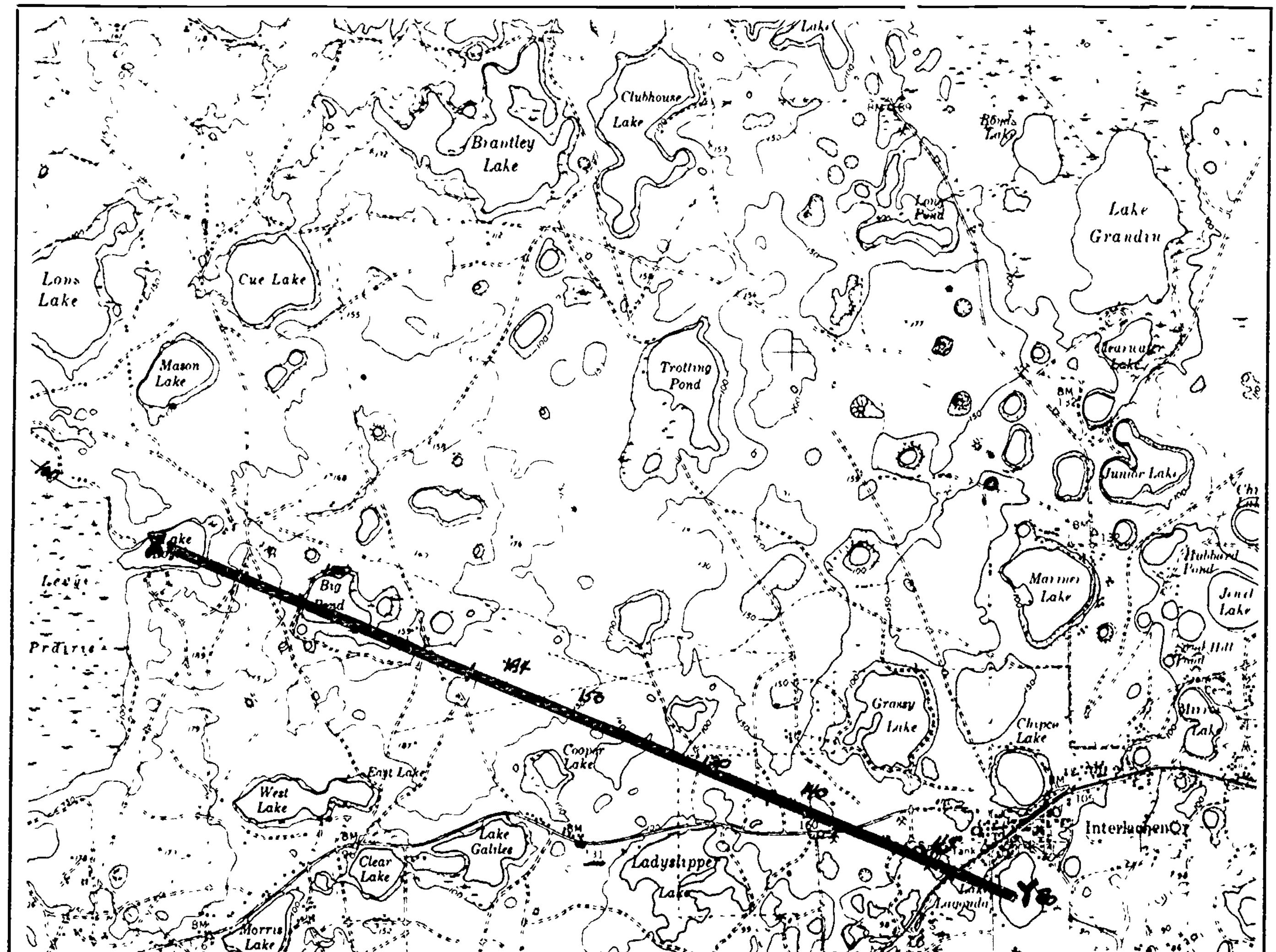
4. At $25.00 a foot, how much would it cost to drill a well to the water table from the top of the 184-foot peak east of Big Pond?

   (184′ - 95′) = 89′ of drilling

   89′ x $25.00/ft. = $2225.00

REFERENCE

Dallmeyer, R. D., *Physical Geology, Laboratory Text and Manual,* Second Edition, 1978, Kendall/Hunt Publishing Co., pp. 195, 198.



GROUNDWATER ACTIVITIES

OBJECTIVE

The participants will measure volume accurately, identify by texture three types of soil, and make visual observations about the water movement through the soil.

MATERIALS

- —3 large polystyrene cups
- —3 plastic coffee can lids
- —3 squares cheesecloth
- —rubber bands
- —water
- —thumbtack
- —watch or clock
- —sand
- —clay
- —gravel
- —pencil
- —four - 250-ml beakers
- —scissors

PREPARATION

This activity should be preceded by a discussion of types of soils, and how water is absorbed into the soil and moves, with time, around the soil particles.

PROCEDURE

1. Using the thumbtack, punch several holes in the bottom and around the lower part of each cup. Make sure you punch the same number of holes in each cup.
2. Place a square of cheesecloth over the bottom of each cup so it covers all the holes. Secure the cheesecloth with a rubber band.
3. Using scissors, cut a hole in the plastic coffee can lid so that the cup just fits inside. Place each cup in a lid, and place each lid over a beaker. Label the cups A, B, and C.
4. Fill Cup A half full of dry sand, Cup B half full of clay, and Cup C half full of a mixture of sand, gravel, and clay.
5. Pour 100-ml of water into each cup. Record the time when the water was first poured into each cup.
6. Record the time when the water first drips from each cup. Note the appearance of the water.
7. Allow the water to drip for 25 minutes. At the end of this time, remove the cups from the beakers. Measure and record the amount of water in each beaker.

HOW DIFFERENT SOILS AFFECT THE MOVEMENT OF WATER

8. Fill out the following chart with students on board.

DATA AND OBSERVATIONS

CUP	TIME		OBSERVATIONS
	WATER IN	WATER OUT	
A			
B			
C			

FOLLOW-THROUGH (QUESTIONS)

1. Which soil sample is the most permeable?
2. Which soil sample is least permeable?
3. How does the addition of gravel affect the permeability of clay?
4. How does soil type affect the movement of groundwater?
5. Can soil type protect groundwater? Which one? How?

REFERENCE

Focus on Earth Science, Teacher's Resource Manual, by Charles E. Merrill Publishing Company, Copyright 1984.

OBJECTIVES

The participants will become familiar with the meaning of the term "water table."

The participants will recognize that the water table is one of the contributing factors in the existence of streams, swamps, and lakes.

MATERIALS

—wide-mouth glass jar
—a glass
—chalkboard and chalk
—crayons
—a mixture of sand and gravel
—water
—paper and pencil

PREPARATION (BACKGROUND INFORMATION)

Groundwater is water that has sunk into the ground and is held under the surface. Rain seeps through the top layers easily. The earth near the surface is loaded with tiny air spaces. Even the rocks have cracks and pores through which water can find its way. But when it reaches clay or impervious rock, it will not sink any farther.

As more water sinks into the ground, it begins to collect above the bedrock or dense soil. When the ground has as much water as it can hold, it is said to be saturated. The ground becomes saturated from the rock or dense soil up, and the top level of this water rises towards the surface. This uppermost level is called the water table. The area of dry ground above the water table is called the zone or aeration. After heavy rains, the table is nearer the surface, and in dry weather it drops again.

PROCEDURE

1. Fill a wide-mouth glass jar three-fourths full of sand and gravel mix. Next, use a glass to pour water down the side of the jar until the water level rises about half way up the side of the jar. This water level should represent the level of the water table. Use a marking instrument of some kind to mark the present level. Show the students that if you add more water, the water table will rise. (See diagram page 23)

2. On the chalkboard show that wherever the land surface dips below the water table, groundwater flows out to the surface. This forms springs, swamps, or lakes. Also tell the class that during dry weather periods the water table level goes down and some streams and swamps may dry up.

3. Aid discussion about the experiment by asking students to explain how different points in the experiment relate to the actual conditions in the environment.

ILLUSTRATING THE WATER TABLE

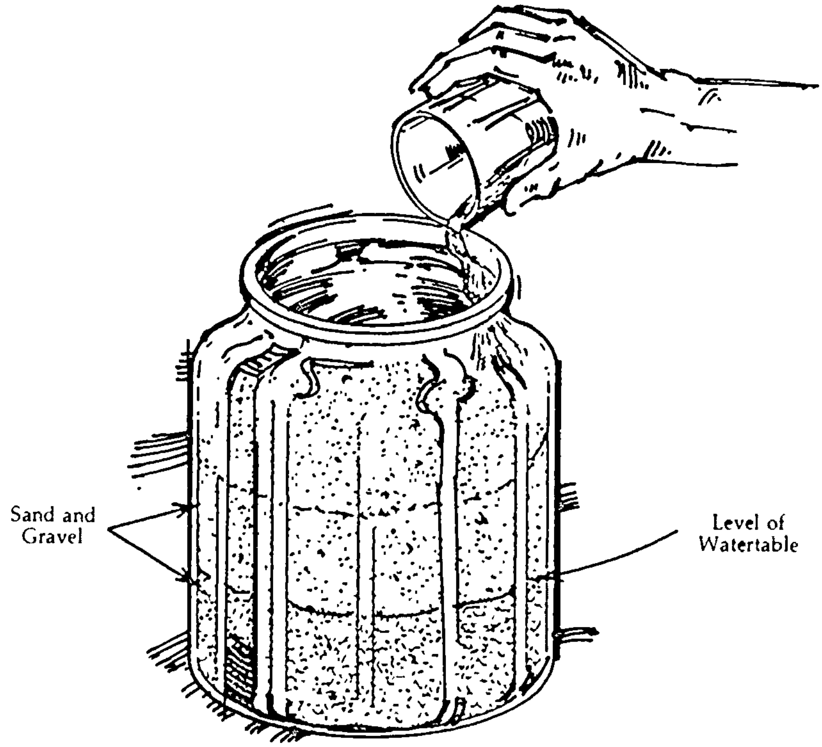
FOLLOW-THROUGH

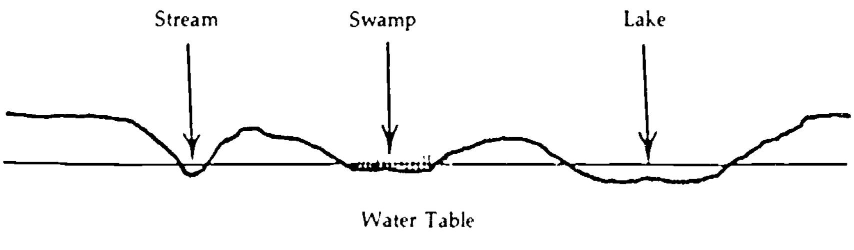
The class may be able to visit a swampy area in the early spring when the water table is very close to the land surface. Sometimes it is possible to reach the water table by digging a small hole with a shovel.

REFERENCES

The World Book Encyclopedia Vol. 7, 1958, p. 3186.

Science for the Elementary School, MacMillan, p. 372 and 373.





OBJECTIVE

To study some characteristics of clay, sand, and gravel related to groundwater by measuring (a) pore space, and (b) permeability.

PREPARATION (BACKGROUND INFORMATION)

The porosity of a rock or rock material tells you how much of its volume is open space. The permeability of a rock is its ability to transmit water or other liquids. Both porosity and permeability are important in relation to groundwater.

MATERIALS

—gravel (or marble chips)
—sand
—clay
—small test tubes
—gas bottles
—funnels
—filter paper
—glassmarking crayon
—test-tube rack
—holder for funnel (ring stand and ring, or tripod)

PROCEDURE

1. Measuring pore space in gravel, sand, and clay.

With a soft crayon or piece of scotch tape, place a mark about halfway up the sides of a small bottle, beaker, or test tube. Fill the bottle to the mark with water, and then measure the volume of water in a graduated cylinder. This is the volume of that part of the bottle. Record this in the "Total Volume" column of the table below. Dry the bottle.

Now fill the bottle up to the mark with gravel (or marble chips). Fill the graduated cylinder to its top mark with water. Slowly and carefully, pour water into the gravel until the water just reaches the top of the gravel. Note the volume of water used to saturate (fill the pores of) the gravel. Record it in the table under "Pore Space." Divide this by the total volume to compute the percentage of ore space in your sample of gravel.

Repeat the experiment with sand and record your results.

Try the experiment with clay. What happens? ______________________________

____

____

What causes this? ______________________________

____

____

____

POROSITY AND PERMEABILITY

MATERIAL	TOTAL VOLUME	PORE SPACE	% PORE SPACE (Porosity)
Gravel			
Sand			
Clay			

2. Measuring Permeability of gravel, sand, and clay.

Fold a circular filter paper into quarters, open it into a cone, and insert it into a small funnel. Fill the cone with gravel (or marble chips) to about half an inch from its top. Place the stem of the funnel just inside a small test tube or small gas bottle. Note how many seconds it takes to fill the test tube or gas bottle with water by pouring water through the gravel. This can be done either with a watch or by careful counting.

Repeat the procedure with sand.

Try the experiment with clay. What happens? ________________________________

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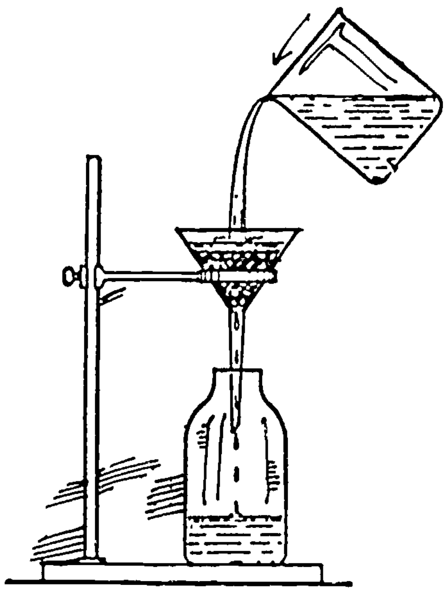


MATERIAL	NUMBER OF SECONDS
GRAVEL	
SAND	
CLAY	

FOLLOW-THROUGH

1. Compare the porosity of your samples of gravel and sand ______________________

____

____

____

2. Compare the permeaı ility of your samples of gravel, sand, and clay. ______________

____

____

____

REFERENCE

Earth Science Activities to accompany *Earth Science*, Samuel N. Namowitz, D.C. Heath and Company, 1981, pp. 25-28.

OBJECTIVE

The participants will show that filtration is a way water can be purified.

MATERIALS

—1 large glass or plastic funnel
—small pebbles
—gravel
—coarse sand
—fine sand
—clean water
—muddy water
—narrow-mouth glass jar

PREPARATION (BACKGROUND INFORMATION)

This is one of the processes which purifies groundwater naturally. Filtration is used by many cities as a water treatment process.

PROCEDURE

1. To a large plastic or glass funnel add a layer of small pebbles, then a layer of gravel, a layer of coarse sand, and finally a layer of fine sand.

2. Pour some clean water through the funnel to allow the layers to settle and pack together.

3. Place the funnel in a narrow-mouth glass jar and pour some muddy water into the funnel. The layers will filter the mud, and clear water will pass into the jar.

FOLLOW-THROUGH

1. Explain that some cities use filtration as a water-treatment method.

2. A water-treatment plant might be visited, or a worker might be invited to visit the class. Participants could report on this method or other treatment methods.

REFERENCE

Science for the Elementary School, 3rd Edition, MacMillan Publishing Company, Inc., Edward Victor, ed.

OBJECTIVE

Participants will show that water picks up invisible materials (dissolved minerals) as it passes through rocks and soil, and these materials are deposited through the process of evaporation.

MATERIALS

—2 filter papers
—2 evaporating dishes (or flasks)
—bunsen burner (or hot plate, alcohol burner, etc.)
—ring stand apparatus (unless using hot plate)
—rock and soil mixture
—graduated cylinder
—funnel

PREPARATION (BACKGROUND INFORMATION)

Water transports both visible and invisible material called its load. This load is picked up by water moving over and through the land. Most fresh water contains dissolved salts (minerals). The water is said to be hard or soft based on the amount of dissolved salts it contains. The invisible load of water can be deposited by the process of evaporation.

PROCEDURE

1. Line a funnel with a piece of filter paper.
2. Pour 50 ml of distilled water through the funnel and catch the filtered water in an evaporating dish.
3. Evaporate the filtered water over a low heat source and observe if any residue remains on the dish once all the water is gone.
4. Line your funnel with another piece of filter paper.
5. Add approximately 20 grams of rock and soil mixture to the filter paper.
6. Pour 50 ml of distilled water through the rock-soil mixture and catch the water in an evaporating dish.
7. Evaporate the filtered water over a low heat source and observe if any residue remains.
8. Compare the results of both evaporating dishes.

**NOTE. To insure very dramatic results, you may elect to mix a soluble salt such as sodium chloride to the rock-soil mixture.

THE INVISIBLE LOAD

FOLLOW-THROUGH

1. Compare the ability of hard and soft water to make soap lather.
2. Explain why the ocean is saltier than most fresh water lakes or rivers even though the ocean gets some of its water from fresh water sources.
3. Do a report on the effect of dissolved salts on water quality.
4. Investigate the formation of sink-holes and underground caves (karst topography).
5. Investigate the formation of stalactites, stalagmites, travertine, geyserite, and petrified wood.

REFERENCES

Bernstein, Leonard, and Wong, Harry, *Earth Science*, Prentice-Hall, New Jersey, 1979.

Brown, F. Martin, and Kemper, Grace H., *Earth Science*, Silver Burdette Company, New Jersey, 1979.

Namowitz, Samuel N., *Earth Science. The World We Live In.* American Book Company, New York, 1975.

WELLS AND GROUNDWATER GRADES 5-9

OBJECTIVE

The participants will demonstrate the flowing of groundwater into a well and how this relates to groundwater level.

MATERIALS

—pencil
—fine wire screening
—small wire for fastening
—medicine dropper
—drinking glass
—coarse sand
--water

PROCEDURE

1. Roll a piece of screening around a pencil to make a cylinder.
2. Enlarge the cylinder so it is about ½″ in diameter and fasten a piece of wire around it to keep it from unrolling.
3. Place the cylinder upright in a glass and then fill the glass with sand, keeping the sand out of the cylinder.
4. Pour water into the sand. The sand will take up the water but the water will also go into the cylinder. . . your well.
5. If you removed water from inside the cylinder, additional water should go into it from the sand, but the level of water in your well would be lower than at first.
6. Raise the water level again by pouring more water into the sand and observe the level in the well.

FOLLOW-THROUGH

1. Find out the depth of the water table in your locale.
2. Ask people with wells how deep they had to drill to reach water.
3. Talk to a well-driller to find out more information about wells and groundwater levels.
4. Plan a field trip to see a well being drilled or dug.

REFERENCES

Branley, Franklyn M., *Water for the World*. New York; T. Y. Crowell, 1982.
"Well." *World Book Encyclopedia*, 1978, 21 pgs. 157.

WATER QUALITY

ACID RAIN—HOW ACID IS IT? GRADES 7-12

OBJECTIVE

The participants will determine how acidity and pH relate to acid rain and its effects.

MATERIALS

—pH paper with specimen colors on the dispenser (or a color indicator chart for pH)
—beakers or jars
—common substances such as. vinegar, ammonia, tap water, rain water, groundwater, soft drink cola, lemon juice. and dissolved baking soda*
—marble chip or penny

*Any other substances in which the pH would vary below and above pH 7 would substitute.

PREPARATION (SEE BACKGROUND INFORMATION)

PROCEDURE

1. Using pH paper with specimen colors, determine the pH value for each substance (each substance should be placed in a separate jar or beaker).

2. Rank each substance in order of acidity or alkalinity by drawing a color bar indicating the various color specimens for the various levels of pH. Along this bar, mark and label each substance tested and its pH.

3. Next, place a marble chip or penny in each substance and observe in 48 hours. Compare how each substance affected the material placed in it. Compare your results with the various levels of the color bar you made to note how the effects of each pH level affected the substance placed within.*

*Divide the substances in 2 beakers or jars and do marble chip/penny procedure for each. Compare results.

FOLLOW-THROUGH

1. You may wish to continue this activity by selecting other substances for pH and their effects on various objects placed within them.

2. You may also wish to draw a graph, noting the variation of effects which were cause by different pH levels on each substance.

3. Discuss how adding acid/alkaline compounds to water changes its quality.

REFERENCES

Acid Rain - A Teacher's Guide, National Wildlife Federation, 1983.

Acid Rain - What It Is - How You Can Help!, National Wildlife Federation, 1983.

Acid Rain (pamphlet) National Wildlife Federation, 1983.

ACID RAIN—HOW ACID IS IT?

BACKGROUND INFORMATION

A. Definition—

Acid rain is caused by the conversion of sulfur oxides and nitrogen oxides in the upper atmosphere into sulfuric and nitric acid. These acids come to the earth in the form of rain, snow, fog, and dry fallout.

B. Sources of Acid Rain—

The major sources of sulfur oxides are coal-burning power plants and industrial boilers. The major sources of nitrogen oxides come from automobiles and coal-fired boilers.

C. Related Problems Caused by Acid Rain—

The most sensitive areas in North America to acid rain damage are those where acid rain falls on shallow soils and granite bedrock, as well as in lakes which lack the ability to buffer the acid.

D. Effects of Acid Rain—

1. Acid rain is killing animal life in lakes.
2. Acid rain affects vegetation.
3. Acid rain is a threat to people.
4. Acid rain causes economic losses.

E. Solution to Acid Rain—

Acid rain is not a new phenomenon. It used to be a local problem in areas downwind of power plants and other industries. But the use of tall smokestacks that send the pollution high into the atmosphere has turned it into a problem over much of North America.

The rain falling over the eastern United States and neighboring areas of Canada is 10 to 100 times more acidic than normal. There are some storms in which the rainfall is 1,000 times more acidic.

The most cost-effective (and the only reliable) solution to the problem of acid rain is to control the offending pollutants at their source. The goal must be to emit fewer sulfur oxides and nitrogen oxides into the air so that fewer acids form in moisture-laden atmospheres to rain down on vulnerable ecosystems.

ACID RAIN—HOW ACID IS IT?

Measuring pH to determine acidity.

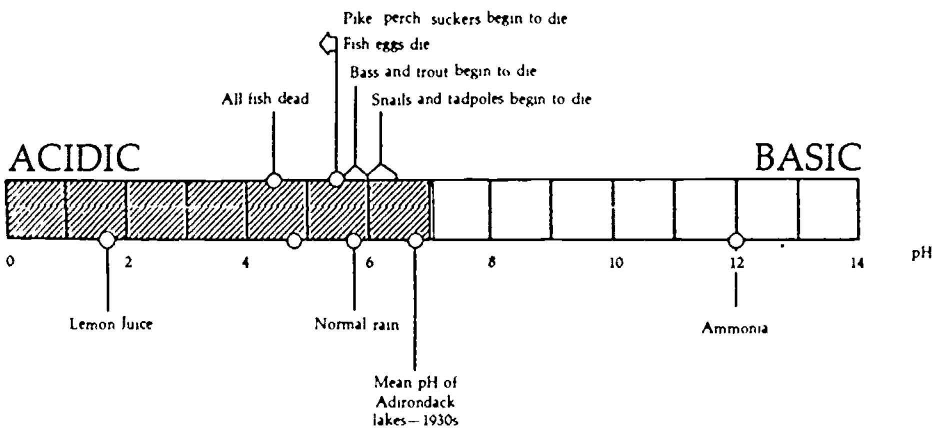
a. Acid is measured on a pH scale ranging from 0 to 14—0 is extremely acid, 14 is extremely alkaline or basic; and 7 is considered neutral.

b. As the numbers move from 7 to 6 to 5, etc., the substance shows greater acidity; likewise, if the numbers move from 7 to 8 to 9, etc., the substance shows greater alkalinity.

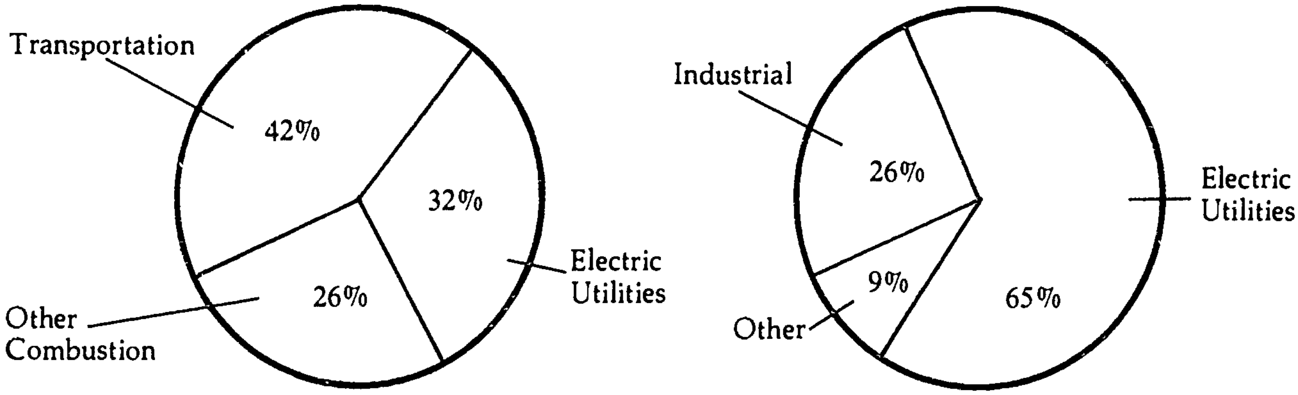
c. The pH scale is designed so that every one-unit drop in pH represents a 10-fold (logarithmic) increase in acidity. For example, pH 6 is 10 times more acid than a pH 7; pH 5 is 100 times more acid than pH 7, etc.

Acid Rain and pH—Uncontaminated rain is slightly acid, pH 5.6. But because of air pollution, rain in most of this country is much more acidic than normal. The following chart indicates various pH levels and each one's effects.

THE pH SCALE AND ACID RAIN.

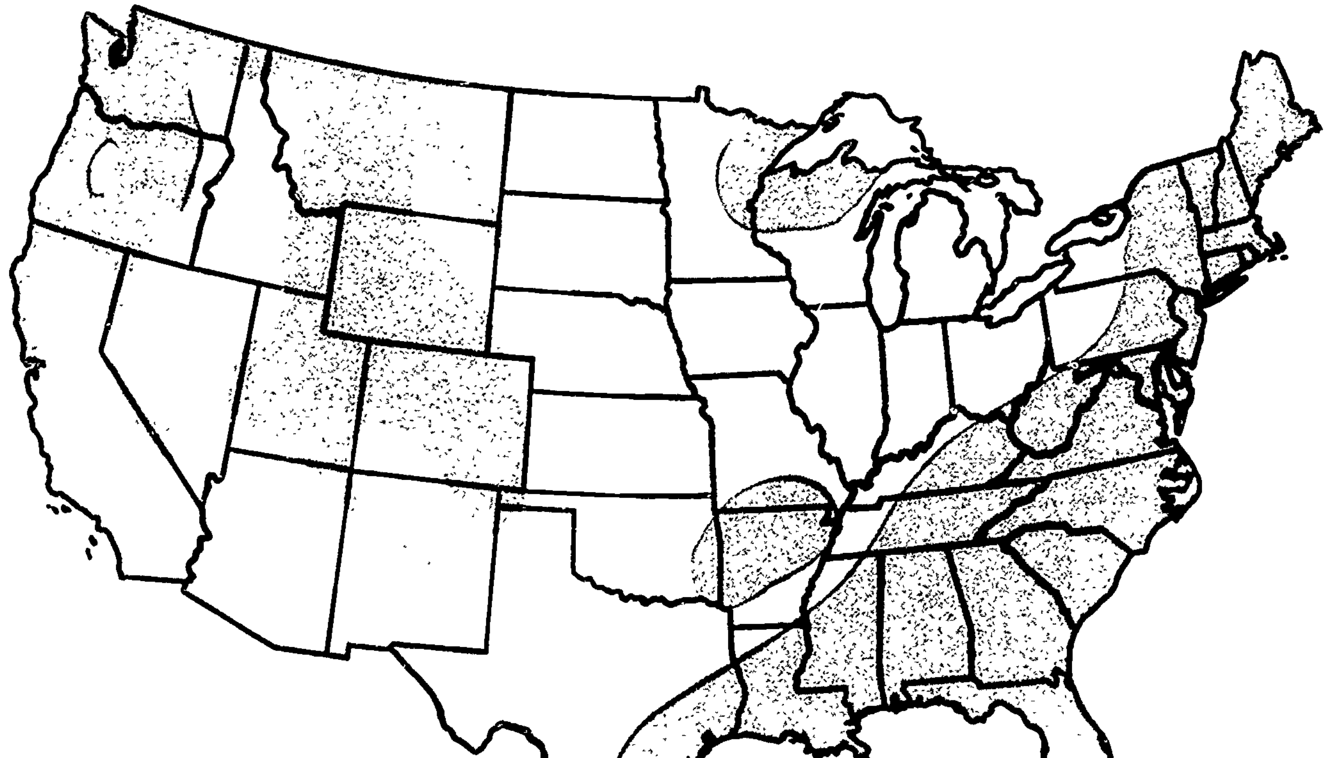


Sources of NO_x and SO_2 Precursors to Acid Rain.



Nitrogen Emissions
Totaled 24.5 million tons/yr.

Sulfur Dioxide Emissions
Totaled 29.7 million tons/yr.



This map illustrates those regions of the U.S. which are sensitive to acid rain

Note 1978 Data
Source Modified from National Commission on Air Quality 1981

SENSITIVITY SCALE

- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity

OBJECTIVE

The participants will demonstrate the procedure for testing for carbon dioxide (CO_2) and use it to test various water samples for its presence.

MATERIALS

—200 ml beaker
—2 droppers
—phenolphthalein solution
—sodium carbonate (Na_2CO_3) solution
—3 different samples of water labeled A, B, C

PREPARATION

Read and discuss pollution in water—its sources, extent of pollution, and its effects (how CO_2 is harmful to aquatic life). Water which is polluted will usually have high levels of CO_2, which can be harmful to animals living in the water.

PROCEDURE

Break class into groups and perform the following steps:

1. Pour 100 ml of water sample A into a beaker.

2. Add 10 drops of phenolphthalein to the water sample. Mix by swirling. NOTE. If a light pink color appears in the water and remains after a one-minute wait, the water sample has *no* CO_2 gas present. Record this as zero in your data chart. (See page 36 for Chart)

3. If no pink color forms, measure the amount of CO_2 by doing the following:

   (a) Using a dropper, add sodium carbonate solution to your water sample one drop at a time. Swirl the sample after each drop.

   (b) Count the number of drops of sodium carbonate (Na_2CO_3) needed to form a light pink color in the water. NOTE. A light pink color may form first but then disappear in a few seconds. Continue adding drops of Na_2CO_3 only until the pink color remains.

   (c) Record the number of drops used in your data chart.

4. Repeat steps 1 to 3 with Sample B.

5. Repeat steps 1 to 3 with Sample C.

CARBON DIOXIDE IN WATER

DATA CHART

WATER SAMPLE	NO. OF DROPS OF Na_2CO_3 ADDED
A	
B	
C	

FOLLOW-THROUGH (QUESTIONS)

1. Where does the CO_2 come from in nature?
2. How does CO_2 get into rivers, lakes, etc.?
3. How many ways have humans polluted lakes, rivers, or streams?
4. How do you test for the presence of CO_2 in water?
5. Bring in newspaper and magazine articles about water pollution.

REFERENCE

Kaskel, Albert, *Principles of Science*, Charles E. Merrill Publishing Company, Columbus, Ohio, 1983.

OBJECTIVE

The participants will use the basic techniques involved in determining the bacterial count in water to distinguish the coliform bacteria from the other types.

MATERIALS

—Kit #76-6350 Water-Bacterial Pollution Kit from Carolina Biological Supply Company has all the needed materials included in the kit (except the water) for a class of 30. Cost is about $15.00.

—water samples from springs, wells, or other sources if desired.

PREPARATION

A. First review with the participants the basic types of bacteria and their importance, bringing out the role of coliform bacteria as being the indicators of water contamination by either domestic or agricultural sewage. The amount of detail at this point would be dependent upon how this activity is being used—as a part of a unit on groundwater or as a unit on bacteria.

B. Next review basic bacteriological lab techniques such as how to inoculate a bacterial plate with minimum contamination. The kit mentioned above has both a teacher's manual and student guides. It also includes sterile collecting bottles, medium, and petri dishes.

PROCEDURE

1. The sterile collecting bottles are to be distributed to the students with instructions on where and how to collect their water samples.

2. When the water is obtained, the participants can follow the student guides in inoculating the sterile plates. Both a total plate count of bacterial numbers and a differential count of the gram negative coliform bacteria can be done with this kit. This will enable the participants to distinguish the coliform colonies from the other bacteria.

3. Incubate the plates and observe. Make a count of the number of colonies obtained.

COLIFORM BACTERIA DETERMINATION

FOLLOW-THROUGH

A. The participants may try to identify the source of contamination in their water samples (locate septic tanks, barns, pastures, etc.).

B. A Gram-stain (or other type bacterial stains) could be made of the bacteria grown on the plates. Then the participants could view the bacteria under the microscope.

C. The participants may wish to conduct other tests on the groundwater such as pH, nitrates, phosphates, or other chemical tests.

D. A field trip to the local water treatment plant could be arranged so that the participants can see the importance of cleaning and treating water properly before human consumption.

REFERENCES

Otto, James, Albert Towle, and Myra Madnick, 1977. *Modern Biology*. Holt, Rinehart and Winston, New York, pages 182-194.

Wedberg, Stanley, 1976. *Introduction to Microbiology*. Reinhold Publishing Corporation, New York, pages 196-230.

Wilson, James, 1982. *Ground Water, A Non-Technical Guide*. Academy of Natural Sciences, Philadelphia.

DOES ACID RAIN AFFECT GROUNDWATER? GRADES 8-12

OBJECTIVES

The participants will be able to describe how soil acts as a buffer for acid rain.

The participants will be able to apply knowledge of acid rain to their area of residence.

MATERIALS

—3 coffee cans (open at both ends)
—3 pieces of tightly woven cloth
—3 flat pans (pie pans)
—approximately 1 liter of each of the following: sandy soil, clay, and loam
—100 ml graduated cylinder
—sulfuric acid
—pH meter or indicator solution

PROCEDURE

1. Adjust pH of water to that of acid rain (approximately 5.0 or less) by adding sulfuric acid.
2. Tie a piece of cloth over one end of each can.
3. Fill each can 1/3 to 1/2 full of a particular type of soil. Label each type.
4. Hold the cans over the pie pans and pour 100 ml of water and sulfuric acid solution into each can.
5. Test the pH of the solution that passes through the soil in each can.

FOLLOW-THROUGH (QUESTIONS)

1. Does soil act as a buffer for acid rain that infiltrates to groundwater supplies?
2. If so, which type of soil tested is the *best* buffer?
3. Do you think that, after repeated application of acid rain, the soil will continue to act as a buffer? Make hypothesis and design your own experiment and follow up.

REFERENCE

Adapted from. *Earth Science - A Search for Understanding*. Walker R. Brown, Norman D. Anderson, Lippencott Co., 1971.

OBJECTIVE

Participants will show how gases dissolved in water can turn that water into an acid.

MATERIALS

—medicine dropper
—water (5 ml)
—small candle
—glass jar
—bromothymol blue
(see local high school chemistry teacher for this)
—graduated cylinder (10 ml)
—test tube
—matches
-glass plate (15 x 15 cm)

PREPARATION (BACKGROUND INFORMATION)

Acid rain is a very real problem in east Tennessee. Gaseous pollutants (such as nitrogen oxide and sulfur oxide from auto and factory emissions) in the air dissolve in rain as it falls. The resulting acid rain affects not only the plant life on earth but raises the acid level in lakes and in streams where it can prove hazardous to the water life.

PROCEDURE

1. Add drops of bromothymol blue to 5 ml of water in a test tube until the water becomes light blue. Explain to the participants that in the presence of an acid the bromothymol solution will turn yellow.

2. Set a small candle in a glass jar. Light the candle and place a glass plate over the jar. (Review with the participants that a candle gives off the gas carbon dioxide.)

3. After the candle goes out, add the bromothymol blue solution in the test tube to the jar. Replace the glass cover and shake the jar vigorously.

4. Observe what happens.

MAKING ACID RAIN

FOLLOW-THROUGH

Participants should observe that the water turns yellow. Explain that other gases in the air also dissolve in the water, changing the water to an acid as the carbon dioxide did. Relate to the class that nitrogen oxides and sulfur oxides are two gases found in the air that produce acid rain. Then review these questions.

1. What gas caused the water to turn acid? (carbon dioxide)

2. Name two other gases that make water acid when they dissolve. (nitrogen oxides and sulfur oxides)

REFERENCE

Daniel, Lucy, *Principles of Science: Book 2*, Columbus, Ohio, 1983, p. 146.

OBJECTIVES

After completion of this activity participants should be able to:

1. list sources of nitrates in groundwater.

2. state problems caused by nitrates in groundwater.

3. determine quantity of nitrates in a sample of groundwater using the LaMotte Test Kit for Nitrates and Phosphates or other suitable method.

MATERIALS

—LaMotte Test Kit for Nitrates and Phosphates (other kits can be used)
—sample of groundwater
—sample of surface water
—containers for samples
—fertilizers such as ammonium nitrate or sodium nitrate

PREPARATION

This material may be presented as a lecture or as a discussion of water quality.

I. Sources of Nitrates

A. Natural

1. Animal Wastes

2. Fixation in Atmosphere. Since the atmosphere is 78 percent nitrogen (N_2), fixation is not uncommon during electrical storms where atmospheric oxygen (O_2) combines with the nitrogen to form a nitrogen-oxygen compound (NO_2). This compound then combines with rainwater to form nitric acid (HNO_3). The nitric acid reacts with soil minerals forming nitrates.

3. Fixation in Soil. Nitrogen-fixing bacteria on legumes account for most natural soil nitrates.

NITRATES IN GROUNDWATER

B. Addition by Man

1. Fertilizers—Since nitrates are essential for plant growth, many are added to the soil for agricultural purposes.

2. Wastes

   a. Animal feedlots. While waste from an animal feedlot may be considered natural, the concentrations of these wastes on recharge areas may put an excessive amount of nitrates in the aquifer.

   b. Septic tanks. It is estimated that 19.5 million septic tank systems put more than 800 billion gallons of waste water into the ground each year. In recharge areas, this waste water may reach the aquifer, accounting for excess levels of nitrates.

II. Dangers of Nitrates

A. In Drinking Water

1. Nitrates are changed to poisonous nitrates in the human stomach.

2. An excessive level of nitrates may cause methemoglobinemia in children less than 6 months of age (methemoglobinemia is a "blue baby" syndrome).

3. Nitrate levels of 10 ppm (parts per million) or greater are consiuered unsafe by U.S. Department of Health Service Drinking Water Standards.

B. In Surface Water

1. Excessive nitrates in surface water tend to act in conjunction with phosphates to promote excessive growth of plants and algae. The death and subsequent decay of this life may deplete oxygen levels, making the water unsuitable for other aquatic life. Runoff is the major source of this pollution; excessive levels of nitrates in an aquifer would contribute to the problem.

PROCEDURE

1. For demonstration of the effects of excessive nitrates on surface water, collect samples of water from various areas where nitrate contamination is likely to differ—for example, farm ponds vs. mountain streams. Or collect water from one source and add fertilizer to one sample while keeping the other as a control. In either case, the sample with the larger amount of nitrates should exhibit more rapid algae growth.

2. Determine concentrations of nitrates in water from various sources using a LaMotte Test Kit for Nitrates and Phosphates. These test kits are available from science supply companies.

NITRATES IN GROUNDWATER

FOLLOW-THROUGH

After completion of this activity, ask the participants to:

1. explain the presence of natural nitrates in groundwater.
2. report on nitrogen fixation of legumes.
3. research the chemical reactions involved in converting atmospheric nitrogen to soil nitrates.
4. debate such things as animal feed lot location and limitation of use of fertilizers.
5. report on septic tank systems in terms of proper types for specific locations.
6. research methemoglobinemia.

REFERENCES

Andrews, William A., *Environmental Pollution*, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1972.

Harte, John, and Robert H. Socolow, *Patient Earth*, Holt, Rinehart and Winston, Inc., New York, New York, 1971.

Renn, Charles E., *Investigating Water Problerms—A Water Analysis Manual*, LaMotte Chemical Products Company, Chestertown, Maryland, 1970.

Wilson, James, *Ground Water—A Non-technical Guide*, Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, 1982.

OBJECTIVE

The participants will determine the total concentrations of suspended solids in a water sample.

MATERIALS

—triple beam balance
—funnel
—filter paper
—one-liter bottle

PREPARATION (BACKGROUND INFORMATION)

A lake with high productivity and fertility is said to be eutrophic. It has a greater abundance of materials than a lake with low productivity and fertility, an oligotrophic lake. To determine productivity, measurements are made of total dissolved solids (T.D.S.), conductivity, total suspended solids (T.S.S.), and turbidity.

The measurement of suspended materials in a body of water helps determine what the productivity, or ability to support life, of that water is. Suspended solids in water consist primarily of living and dead phytoplankton and zooplankton, silt, human and animal excrement, some decaying plants and animals, and a wide range of industrial waste. The total suspended solids of a water sample is the amount of material, by weight, that is suspended (not dissolved) in a given volume of water.

T.S.S. determinations include a variety of solids, which makes it difficult to set "acceptable standards." Wide deviations, sudden or even gradual, from locally established "norms" indicate problems. Values below the norm may be a sign of low productivity in the water. Values above the norm may point to excessive productivity.

Closely related to T.S.S. is a factor called turbidity. A turbidity reading measures the ability of a light beam to pass through the water sample. Water which has materials suspended in it scatters and absorbs light rays entering it, rather than transmitting the light in straight lines. Thus, a turbidity reading can give an indication of the T.S.S. Turbidity in groundwater or surface water means that solids are in the water. These solids may have contaminant which could be harmful to human health. Therefore, keeping turbidity levels low is important for health reasons.

PROCEDURE

1. Collect 1 liter of water from each of a number of locations at your field site.

2. Weigh a filter paper.

TOTAL SUSPENDED SOLIDS

3. Filter a 1-liter sample of water through the weighted filter paper.
4. Allow the filter paper to dry completely.
5. Weigh the filter paper again. The change in weight is the weight of total suspended solids in 1 liter of water. T.S.S. values are commonly expressed in mg per liter.
6. Check with the local governmental agency responsible for monitoring water quality (such as health department, pollution control board, etc.) and ask for the established "norm" of T.S.S. for the body of water you are studying.

FOLLOW-THROUGH (QUESTIONS)

1. T.S.S. value of tested samples: ____________________
   (List T.S.S. value for each sample located at various locations on field site.)

   ____

2. Local "norm" of T.S.S. = ____________________.
3. Compare the values of tested samples and "norm" of T.S.S.
4. What do test samples indicate about water's productivity? Is it high, excessively high, or low? Why? Explain your answer.

REFERENCES

Andrews, William A., ed. *A Guide to the Study of Freshwater Ecology*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Andrews, William A., ed. *A Guide to the Study of Environmental Pollution*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

COMMUNITY IMPACTS

OBJECTIVES

The participants will show that agricultural chemicals are potential pollutants of surface and groundwater in their community.

Participants will gain awareness of the number and type of chemicals used in local agriculture.

PREPARATION (BACKGROUND INFORMATION)

Participant should realize that many sources contribute to contamination of water. Industrial processes, municipal sewer systems, landfill mismanagement, airborne contaminants, and common everyday processes such as washing clothes, dry cleaning, pumping gas, all contribute to the impure conditions found in local surface and groundwater supplies. Participants need to understand that all water pollution does not come from heavily populated urban areas, but that some common agricultural practices of farmers can contribute significantly to the pollution load carried by our water systems. It should also be stressed that most farmers could not remain in business without the use of these beneficial chemicals.

MATERIALS

—pencil
—paper
—scissors
—glue

PROCEDURE

Have participant interview at least one farmer if in a rural setting. Participants in more suburban or urban settings might interview gardeners. The following information should be obtained.

1. What crops does the farmer (gardener) grow?
2. How many acres (sq. ft.) are planted?
3. What chemicals are used by the farmer (gardener) on a routine basis during the cultivating and harvesting of crops?
4. What is the purpose of the chemicals and how are they applied?

The information should be brought back and compiled. (In a given region, the diversity of crops grown and chemicals used should not be a very long list, perhaps 10 to 15 chemicals.)

Some participants will be able to obtain labeling and warning information leaflets that accompany these chemical products. The county agricultural extension agent can supply these materials in most cases, if the farmer cannot. (No packaging containing residues should be brought to class.) These warnings should be organized and displayed on a poster or bulletin board, after fully reading the warnings in class.

Participants will realize how commonly these chemicals are used and how dangerous these substances could be.

FARMERS AND WATER POLLUTION

FOLLOW-THROUGH

1. Where does this chemical go when it rains?

2. What might be an impact of the use of these chemicals on fish and wildlife? Continue the discussion leading to the effect on the food chain.

3. Can the farmer make a living without these chemicals?

4. How are food prices affected by the use of these chemicals?

5. What are solutions to the problem of agricultural pollutants by chemicals?

REFERENCE

David B. Mauney, Mountain Heritage High School, Burnsville, North Carolina.

OBJECTIVE

Participant will show knowledge of the four doctrines of groundwater rights by applying them to a life-like situation.

MATERIALS

—handout (Groundwater Rights)

PREPARATION

Familiarize yourself with the four doctrines of groundwater rights and then discuss with the participants the basic idea of each right.

PROCEDURE

1. Discuss the four groundwater doctrines, before handing out activity sheet. Then, participants should be chosen to play the roles of the factory owners, the landowners, and one for the judge.

2. Have the role-players read the activity sheet and develop ideas for their role. Then allow the judge to question both the factory-owner and the landowner as to their points of view about the situation.

3. You will probably need to give the role-players some assistance with their questions and answers. Some of the questions might be:

   How long have you been located in the area?

   How much water do you normally use each day?

   For what purpose is the water used?

   Does your water use benefit the community in any way?

4. After the questioning period, ask the entire class to review the Four Doctrines of Groundwater Rights and decide which one is the most practical in this situation.

FOLLOW-THROUGH

Have the participants defend their decisions in a paragraph.

REFERENCE

Ground Water Issues and Answers. American Institute of Professional Geologists. Arvada, Colorado. 1983.

GROUNDWATER RIGHTS

ACTIVITY SHEET

The Four Doctrines of Groundwater Rights

1. *Riparian or Common-Law Doctrine*—The person who owns the land that lies on top of a water source has absolute ownership of the underlying groundwaters whenever he chooses to use it, with no limit on the amount he uses.

2. *Reasonable Use Doctrine*—This rule is very similar to the riparian rule but restricts the right to use the water to a use that is reasonable. A landowner's rights would not be limited *except* when the available supply is not enough to meet the immediate demands.

3. *Appropriation Doctrine*—The rule is "first come, first served." The ones that were there and used the water first have the strongest rights to the supply of water when it is limited. It could mean that new wells could be prohibited in areas that are developed with all the possible buildings and homes.

4. *Correlative Rights Doctrine—All* landowners have the same rights to the groundwater that they need to supply their lands that lie on top of the water supply. If too many are trying to use the available water supply, the courts may have to decide how to divide the available supply.

Overriding Rights—In some special cases, other rules may apply.

1. Federal right to water for a land reservation.
2. Indian rights for Indian reservations.
3. Pueblo rights to water supplies in former Spanish territories.
4. Federal rights to water for national security purposes.

SIMULATION

A chemical factory has been located in an area for 50 years. When it first moved into the area, it bought all the land within a wide area. As years passed, some of the area was sold to real estate developers who sold houses to individual landowners. The factory has always pumped the thousands of gallons it uses daily from underground wells. There is no municipal water available. As the number of homes in the area increased, the number of family-owned wells also increased. Landowners are now being forced to dig deeper and deeper to find water, and many wells are being abandoned as they "dry out." The landowners feel it is the fault of the chemical factory, which pumps such an enormous amount of water out of the ground each day. The matter has now been taken to court and you as a judge must decide the correct action to take.

Using the Four Doctrines of Groundwater Rights, make a decision about the discussion you are about to hear. Decide which rule would best apply here and be ready to defend your position to the factory owners and the individual homeowners in a paragraph.

OBJECTIVE

To demonstrate a process of sewage management by use of a settling tank.

MATERIALS

—3 jars
—1 bottle of powdered alum
—filter paper
—1 cup of soil
—funnel
—spoon

PREPARATION (BACKGROUND INFORMATION)

There is such a wide range of groundwater contamination that its prevention will involve many decisions between the general public, experts, and government agencies to bring this problem under control.

Many years ago raw sewage could be dumped into rivers and streams with the hope that nature would purify it. Until recently, the primary sewage treatment method, settling, was sufficient for purifying. However, today we are producing so much sewage that nature can no longer do the job and the primary sewage method is insufficient by itself. We need more treatment plants that process the sewage further and prevent untreated sewage from entering and polluting our rivers and streams.

The following investigation on waste management will illustrate the primary method of sewage treatment by demonstrating how a settling tank works.

PROCEDURE

1. Fill a jar with water; then place a teaspoonful of soil in the jar. Mix the soil and water well, and let the mixture stand for a few minutes. This mixture represents sewage at a treatment plant. The soil will eventually settle to the bottom of the jar.

2. Fill another jar with water, mix in 1 teaspoonful of soil and 1 teaspoonful of alum. This demonstrates how an added chemical, alum in this case, speeds up the settling process.

3. Place a filter in the funnel. Place the funnel in the third jar and pour in the mixture of soil, water, and alum. The water filters through, leaving behind soil "sewage" on the filter, providing further a method for sewage treatment.

FOLLOW-THROUGH

Research your local sewage treatment plant process and arrange for a field trip or a speaker to visit your class.

HOW DOES A SETTLING TANK WORK?

REFERENCES

Pamphlets:

"Ecology: Problems and Progress", American Education Publication Xerox Company. Columbus, Ohio

Teaching Soil and Water Conservation, U.S. Department of Education, Soil Conservation Service, Government Printing Office.

"Waste Management", Teachers Guide, Pollution Control Education Center, Township of Union Public Schools, Union, New Jersey

"McDonald's Ecology Action Pack", McDonalds' Corporation, Dayton, Ohio

"Water Pollution", Teachers Guide, Pollution Control Education Center, Union, New Jersey

"Ground Water Issues and Answers", American Institute of Professional Geologists, 7828 Vance Drive, Suite 103, Arvada, Colorado 80003.

Newspaper articles on:

"Toxic Wastes"
"Landfill"
"Sewer Update"
Greeneville Sun, Greeneville, Tennessee 37743

OBJECTIVES

The participants will demonstrate how precipitation on a landfill can leach chemicals into the groundwater contaminating wells, ponds, and streams.

The participants will list three other important sources of municipal waste contamination.

The participants will define an unsafe and a relatively safe landfill method.

MATERIALS

—box with sand (enough to form a small hillside in box)
—a piece of paper torn into small bits, soaked in red food coloring
—small bowl or saucer partially filled with water
—cup of water
—aluminum foil
—handout on Municipal Contamination (American Institute of Professional Geologists)

PREPARATION (SEE DEMONSTRATION)

Cut away the front of a box, and place sand in the box (slanted). Place a landfill higher than the water reservoir. Place aluminum foil under the sand, overlapping the bowl, so that the "contaminated" (red food colored) water "leached" from the landfill will flow into the clean water below. The aluminum foil will form a trough from the landfill to the reservoir below. Place the bits of paper in the landfill before pouring the water. You should stress to the participants that the landfill material could be there for years before it actually contaminates the water below.

PROCEDURE

1. Hand out sheet on municipal contamination for participants to read.

2. Oral discussion on municipal contamination.

3. Demonstration on municipal waste contamination by pouring water on side without "landfill" FIRST and then on side with "landfill."

4. Discuss observations.

MUNICIPAL WASTE CONTAMINATION

FOLLOW-THROUGH

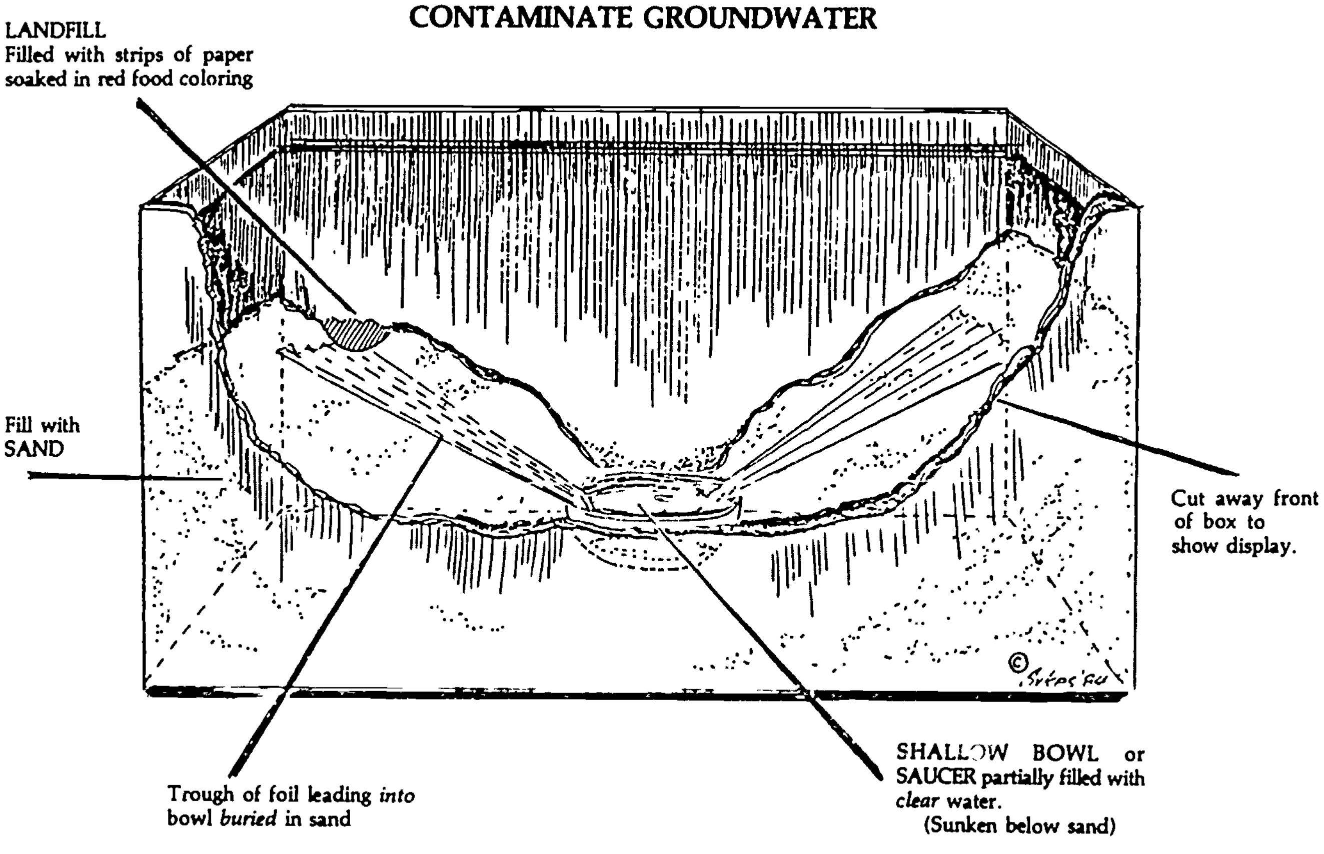
1. Have the students do a demonstration on the relatively safe landfill and on the unsafe landfill.
2. Guest speakers on landfills.
3. Field trip to a landfill.

REFERENCES

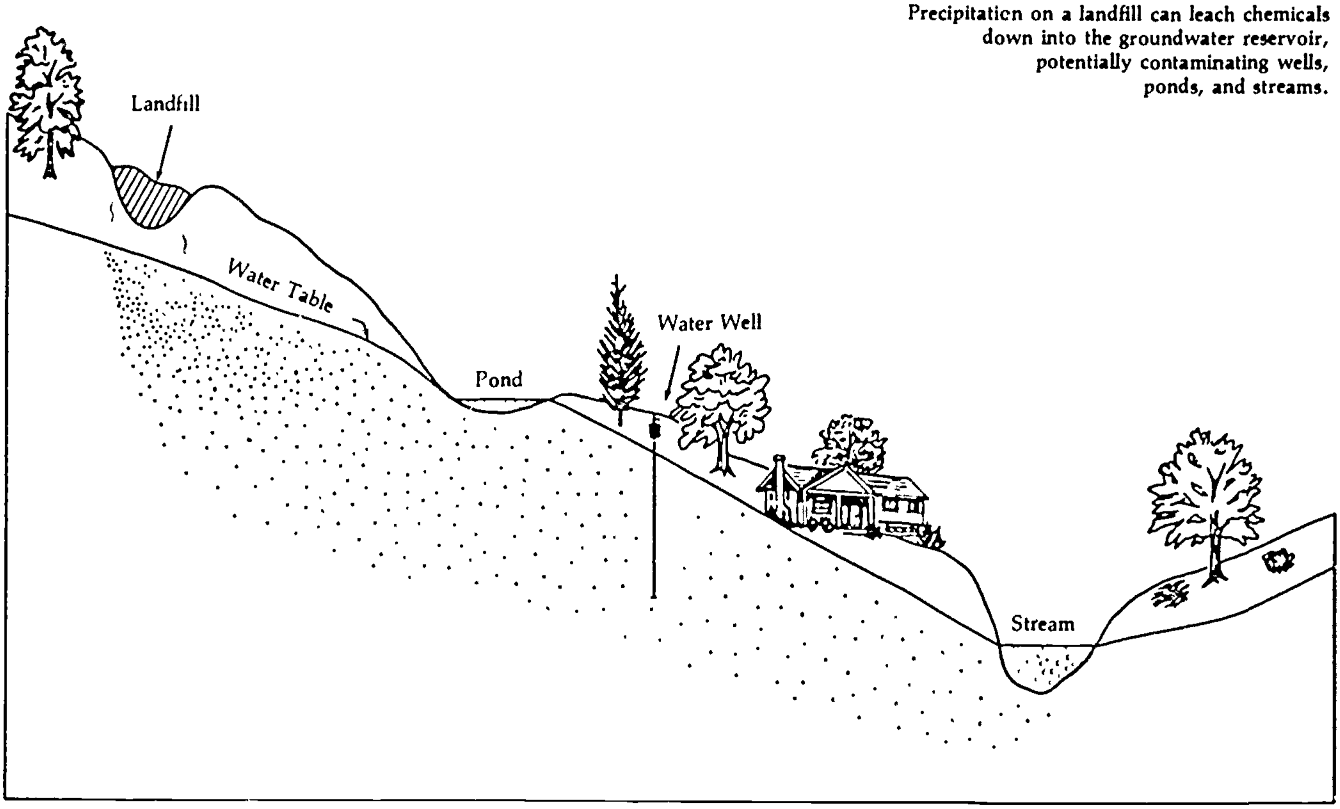
The World Book Encyclopedia, "Groundwater", Vol. 8G, p. 394, copyright 1982.

Ground Water Issues and Answers p. 18, published by the American Institute of Professional Geologists, 1983 copyright.

DEMONSTRATION: HOW PRECIPITATION OVER LANDFILL CAN CONTAMINATE GROUNDWATER

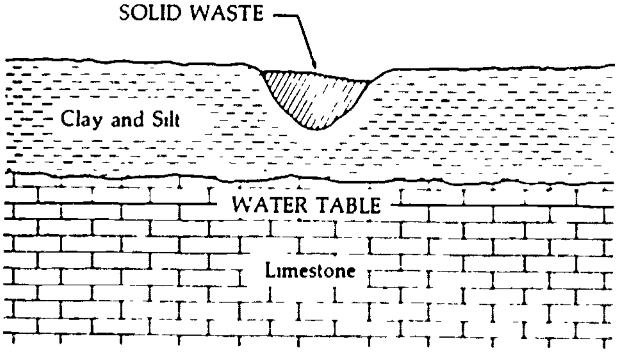


MUNICIPAL WASTE CONTAMINATION

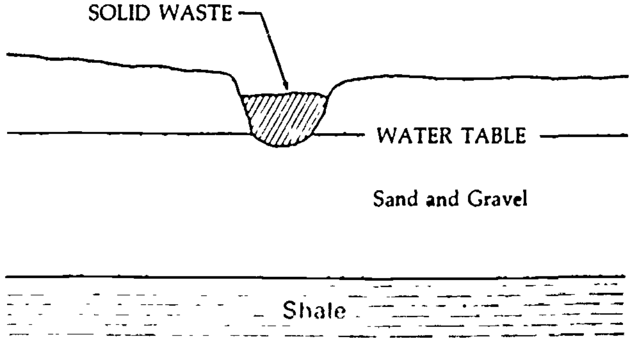


In the humid areas of the country, rain and snow on a landfill may carry dissolved substances downward, delivering biologic, organic, and inorganic pollutants to the ground water. The degree of hazard depends on the geology of the site, design of the landfill, and character of the wastes.

Most municipal trash is disposed of in such landfills. Other important sources of municipal contamination include sewage effluent, sludge disposal, and leaky sewers.



Relatively Safe
Pollutants move slowly in clay and silt and many noxious compounds are absorbed on clay-mineral grains.



Unsafe
Pollutants entrained directly in ground water.
(Illustrations from USGS Circular 601-F)

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS
7828 Vance Drive Suite 103 Arvada Colorado 80003
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POLLUTED PONDS LEAD TO POLLUTED GROUNDWATER — GRADES 4-6

OBJECTIVE

The participant will observe and record (by use of a demonstration) how ponds (and eventually groundwater) become polluted from oil, chemicals, and detergents.

MATERIALS

—8 pint jars (4 with tight-fitting lids)
—masking tape
—pencil
—water
—funnel
—1 tablespoon of oil
—1 tablespoon of vinegar
—1 tablespoon of laundry detergent
—1 cup soil

PREPARATION (BACKGROUND INFORMATION)

There are many ways in which water becomes polluted. First, there is natural pollution. Soil, leaves, and tiny organisms get into water from nearby land. Then, there is pollution caused by people. In farm areas, fertilizers and insecticides get into streams and lakes. So does runoff from animal feed lots. In industrial areas, harmful wastes are dumped into the water from factories and refineries. In cities, sewage and runoff from trash dumps find their way into the water. This, in turn, seeps into the groundwater, which is where a number of cities and most rural areas get their drinking water. Pollution of water is a very serious problem.

PROCEDURE

Follow these steps to make your own polluted pond water and see what pollution can do to our groundwater. Record findings on the chart below on the chalk board.

1. Label 2 jars each 1, 2, 3, and 4 with masking tape. Fill one set of jars (1-4), with lids, halfway with water.
2. Observe the water in jar 1. Describe it in the chart.
3. Put the oil in jar 2, tighten the lid and shake the jar. What did you observe? Record your findings on the chart.
4. Put the vinegar in jar 3, tighten the lid and shake the jar. What did you observe? Record your findings.
5. Put the detergent in jar 4; again tighten the lid and shake the jar. Record your findings.

HOW CLEAR IS THE SOLUTION?

Jar 1 ______________________

Jar 2 ______________________

Jar 3 ______________________

Jar 4 ______________________

POLLUTED PONDS LEAD TO POLLUTED GROUNDWATER

The following steps will illustrate how the polluted pond water affects the groundwater.

6. Put soil in funnel and place funnel on empty jar 1.
7. Pour contents of jar 1 (water only) through funnel, let drip into glass. Fill out another chart like the first one, starting with jar 1, etc.
8. Move funnel with soil to empty jar 2. Pour contents of jar 2 (oil and water) into funnel. Observe and record.
9. Repeat steps with jar 3 (vinegar) and jar 4 (detergent). Observe and record.
10. Compare findings on each chart.

FOLLOW-THROUGH (QUESTIONS)

1. If these elements were added to a real pond and seeped into the groundwater, how would it affect the water in the pond and the ground?
2. How would animals/people be affected?
3. Why did we use the same soil?

REFERENCES

Holmes, Neal. *Gateways to Science* Webster Division, McGraw-Hill Book Company, 1979.

McClung, Margo. "Science Experiments and Nature Studies", *MacMillan Instant Activities Program,* MacMillan Publishing Company, New York, 1982.

OBJECTIVES

The participant will be able to read contour maps and trace the water table.

The participant will list possible pollution problems that can occur when hazardous wastes are not disposed of properly.

MATERIALS

—handouts (Pollution of Groundwater, Topographic map)
—paper/pencils

PROCEDURE

1. Hand out activity sheets on an individual or group basis.
2. Complete activity.
3. Discuss.

FOLLOW-THROUGH

This activity could be set up as a panel discussion, and roles could be assigned to participants to discuss the feasibility of the location of the plant.

REFERENCE

Gary Barrigar, Elizabethton High School, Elizabethton, Tennessee.

POLLUTION OF GROUNDWATER

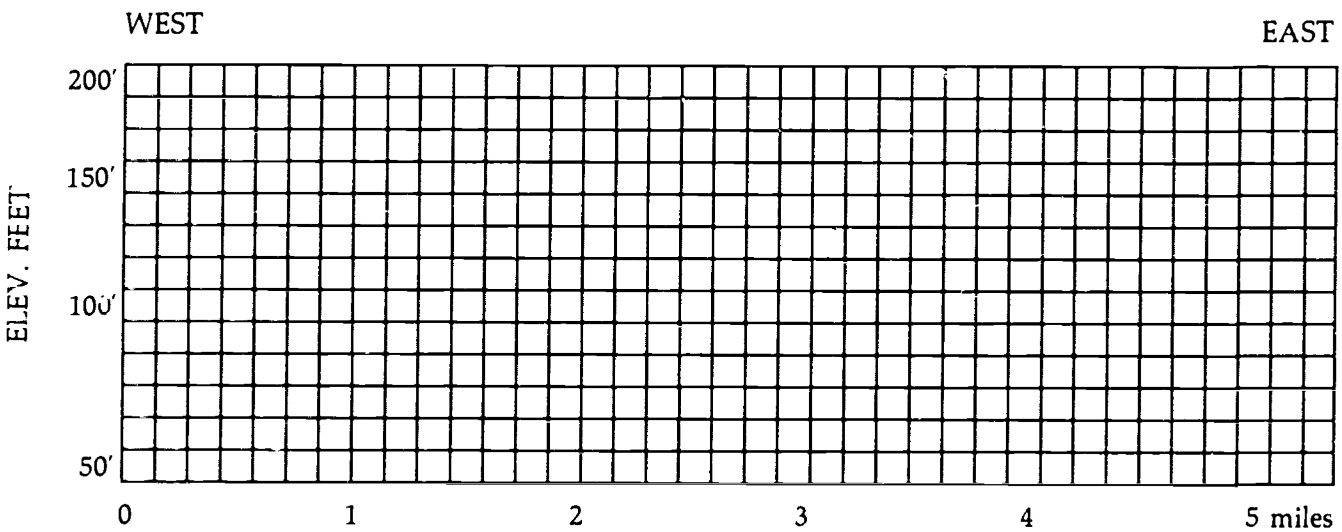
Water finds its own level, underground as well as on the surface. Many factors affect the level of groundwater, such as the presence of aquifers, different rates of percolation from the surface, pumpings from wells, etc. This exercise considers a simple situation where the water table is easy to trace.

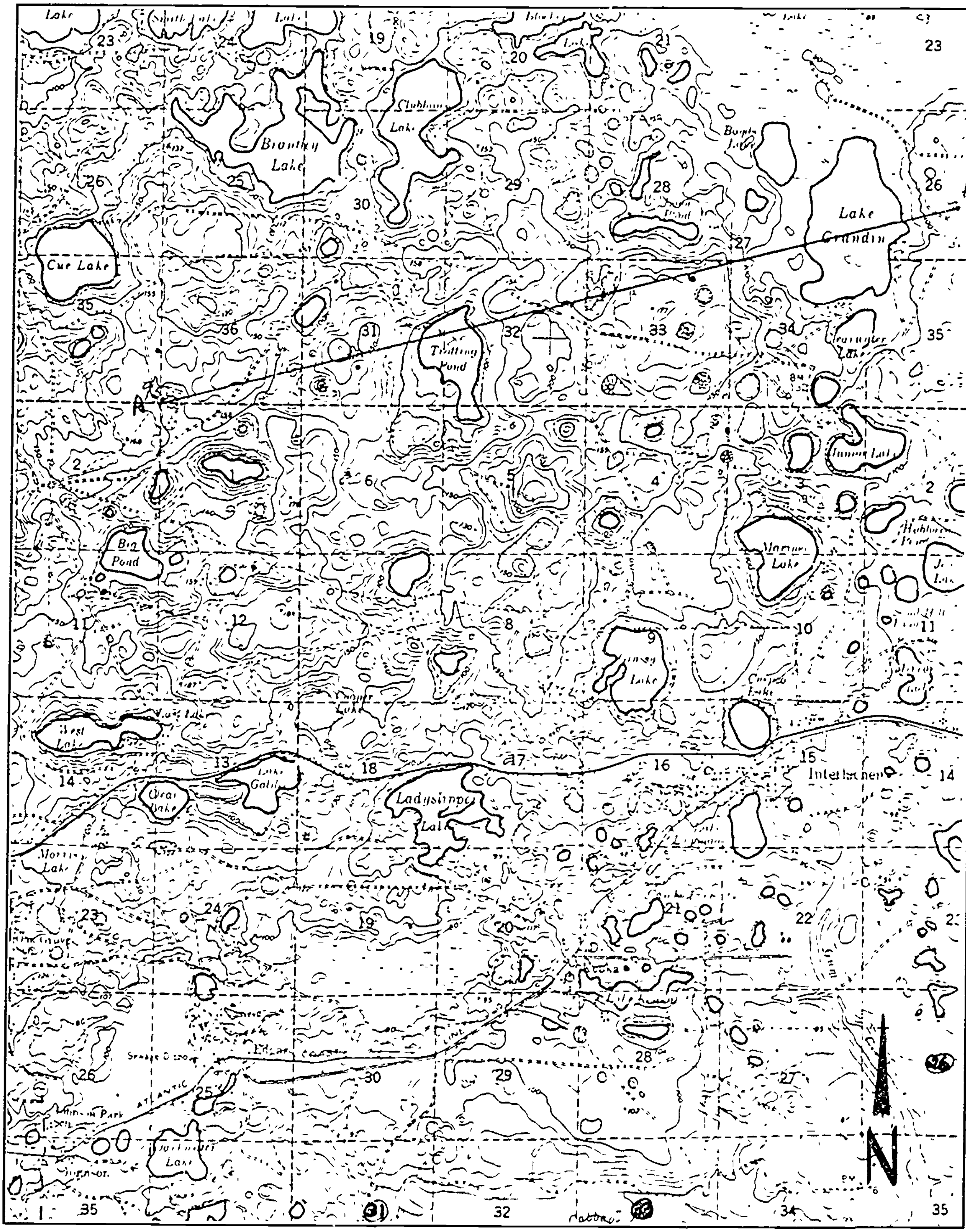
This area is one of limestone bedrock in which many sinks are present. Some of the sinks contain lakes, some are dry. Assuming that the lakes are interconnected with the water table, answer the following questions.

1. On the grid below, draw a profile along a straight line beginning at the southwest corner of Section 36 (about 1.5 miles southwest of Brantley Lake in the northern half of the map area), passing through the northeast corner of Section 33 (between Trotting Pond and Lake Grandin), and ending at the 110-foot contour line in Section 26 near the east margin of the map. When you have completed the profile, draw a dotted line on the profile showing the position of the water table.

2. A chemical company plans to locate a small chemical processing plant in Section 31 on the line of your profile between the two hills outlined by the 150-foot contour lines. The plant designers plan to obtain their water supply from a well at the plant site, and to dispose of their waste liquids by a pipeline to the small dry sink hole located about ½ mile southwest of the plant on the profile near the west boundary of Section 31.

   Comment on the advisibility of this plan in terms of any potential pollution problems that may arise if this plan is carried out. Use your profile to show the proposed plant site, the water supply well, and other evidence that may help in explaining your comment.





GROUNDWATER ACTIVITIES

GROUNDWATER GLOSSARY

1. *Aquifer*—A geologic formation capable of storing and transmitting significant volumes of water.
2. *Condensation*—The process whereby water is changed from a gas (water vapor) to a liquid.
3. *Dissolved minerals*—Minerals (salts included) that are in solution in water.
4. *Dissolved oxygen*—The amount of oxygen in solution in water.
5. *Eutrophication*—A process which results in a water body which is very rich in nutrients, seasonally deficient in oxygen, and generally shallow.
6. *Evaporation*—The process whereby water is changed from a liquid to a gaseous state (water vapor).
7. *Groundwater*—Water contained in the zone of saturation.
8. *Hydrologic cycle*—The continuous process involving the circulation of water in oceans to the atmosphere to the land and back to the sea.
9. *Hydrology*—The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
10. *Impervious rock*—Layer of rock generally considered under normal situations to be incapable of being penetrated.
11. *Percolation, Infiltration*—Downward flow or seepage of water through the pores or spaces of rock or soil.
12. *Permeability*—The ability of a substance such as soil to transmit water or other liquids.
13. *pH*—A measure of the hydrogen -ion concentration of a substance. A pH below 7.0 is increasingly acidic and above 7.0 is increasingly alkaline (basic).
14. *Porosity*—The percentage of the total volume of a material that is open space.
15. *Precipitation*—Water from the atmosphere that falls to the ground as rain, snow, sleet, or hail.
16. *Recharge area*—An area where water flows into the earth to resupply an aquifer.
17. *Sinks, Sinkholes*—A natural depression in a land surface, generally occurring in limestone regions and formed by the solution or by the collapse of a cavern roof.
18. *Surface water*—All the water on the surface of the earth including snow and ice.
19. *Turbidity*—The ability of a beam of light to pass through a sample of water.
20. *Water table*—The upper boundary of the zone of saturation.
21. *Zone of aeration*—Area between the ground surface and the water table.
22. *Zone of saturation*—Area underground in which every available space is filled with water.

NOTES 12